

# Utility of two-dimensional echocardiography in pregnancy and post-partum period and impact on management in an inner city hospital\*

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## Abstract

**Aim:** Evaluate the practice and appropriateness of requesting echocardiograms in patients with suspected or documented cardiac disease during gestation and puerperium, using the American College of Cardiology Foundation (ACCF) appropriateness criteria, in conjunction with clinical picture.

**Methods:** Retrospective observational study, to analyze echocardiograms performed during pregnancy and puerperium at a teaching hospital from 2001 to 2006 for appropriateness criteria and studying its impact on management. Sixty-seven patients pregnant or in the puerperal stage had an echocardiogram performed during that period; 58 met our criteria for inclusion.

**Results:** Based on clinical information and criteria of the ACCF, 51 of the 58 echocardiograms met the appropriateness criteria. Of the 51, results of 40 impacted on management; 14 of the 40 echocardiograms that had an impact were abnormal.

**Conclusions:** Although the ACCF appropriateness criteria have not been specifically studied in pregnancy, our study demonstrates that the criteria are applicable if used appropriately in pregnancy. Most indications in our study correlated with the appropriateness criteria. Although

most findings were normal, information from echocardiograms impacted on management in the majority of patients, contributing to therapeutic decision-making. The reliability of echocardiograms performed according to appropriate criteria to assist clinical decisions was excellent even in patients with physiologic cardiovascular changes.

**Keywords:** Appropriateness for echocardiography; echocardiography in pregnancy; utility of echocardiography in pregnancy.

## Introduction

Pregnant women with cardiac disease present challenges in management to physicians and obstetricians during gestation, labor and immediate post-partum period. A coordinated multidisciplinary team approach with an individualized combination of obstetrician, physician, cardiologist and anesthesiologist helps provide optimal care. Understanding and anticipating the maternal and fetal outcome of the cardiac patient helps the obstetrician manage these patients appropriately, including the proper utilization of resources pertinent to labor rooms, intensive care unit and invasive cardiac evaluation in the ideal manner.

Echocardiography is a standard non-invasive tool which provides accurate assessment in reasonable time of cardiac morphology and function. Given the fact that echocardiography is a non-invasive modality with no risks to the patient, its overuse is not uncommon [1, 2, 5, 14]. Tendency for overuse or misuse is possible because of ease of availability and safety of the procedure, especially in the absence of indication [5]; examinations also may be requested by non-cardiologists with inadequate knowledge of specific areas where the procedure may or may not provide answers [6, 14].

A study by Churchill et al. which analyzed 21,375 trans-thoracic echocardiography (TTE), found that the requests for TTE doubled between the first and the last full calendar years of the study, emphasizing that the “routine” requests for echocardiograms are common practice in many hospitals [2]. Another study conducted in Wellington Hospital during a 6.5-year period showed an increase in the utilization of echocardiography from 1984 to 1990 as well as an increase in requests from non-cardiologists [20]. The study also revealed that one-

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quarter of the 11,701 echocardiograms performed during the study period showed normal cardiac structure and function [20].

Pregnancy is well recognized to be associated with several unique physiological changes. Pregnancy imposes burden on the cardiovascular system, with the necessary adjustments generally tolerated by healthy women; on the other hand, associated pre-existing cardiac disease may be a different issue and poses the problem in adjustments due to inadequate hemodynamic reserves [18]. Hemodynamic changes during pregnancy include: an increase in blood volume early in pregnancy and rising until mid pregnancy; an increase in cardiac output beginning around the fifth week and increasing until the 24<sup>th</sup> week; an increase in heart rate which peaks during the third trimester; and an associated fall in blood pressure during the first trimester reaching a bottom in the mid pregnancy and rising to prior values just at term [3, 8, 15]. Increase in pulmonary blood flow is balanced by a decrease in pulmonary vascular resistance with unchanged pulmonary artery pressure [18]. Manifestations in pregnancy may include shortness of breath, pedal edema, or even syncope that may be attributed by the physician as cardiac in origin. Because a pregnant woman may present with a wide variety of symptoms, signs and general complaints associated with the physiological changes resulting from pregnancy, and not primarily from cardiac disease, the diagnostic value of echocardiography in this population appears useful, in that it may be helpful in distinguishing cardiac from non-cardiac manifestations.

On the other hand, certain conditions such as peripartum cardiomyopathy, significant cause of maternal morbidity and mortality in the US [9, 19], demand prompt detection by echocardiography for therapeutic interventions. Echocardiogram is a useful procedure that can help differentiate peripartum cardiomyopathy from pulmonary embolism [9]. Pre-syncope is also a possible scenario in a pregnant woman attributed to inferior vena cava compression by the gravid uterus, although, it may also be a result of cardiac disease [8].

Based on the above knowledge, this study analyzed the practice of utilizing echocardiography and its usefulness in management of pregnant and post-partum patients at Lincoln Medical and Mental Health Center (LMMHC), an inner city teaching hospital in the Bronx, New York.

## Materials and methods

In this retrospective observational study, we performed an analysis of all the pregnant patients and patients in the first month after childbirth who had an echocardiogram done at LMMHC from 1 January 2001 to 30 June 2006.

Institutional review board approval was obtained. Using discharge codes, echocardiography records, and a computerized

database, we identified pregnant and post-partum women who had an echocardiogram. The records of these patients were reviewed to determine the reason for request of the study and its impact in the further management of the patient. Clinical data, including age, race and parity, as well as information on timing of presentation in relation to gestation and pregnancy outcome was recorded. The physician who reviewed the echocardiogram indications was blinded regarding the department who made the requests. Patients who did not have an available echo report or complete clinical data were excluded from our analysis.

We used the ACCF Quality Strategic Directions Committee Appropriateness Criteria Working Group, American Society of Echocardiography, American College of Emergency Physicians, American Society of Nuclear Cardiology, Society of Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and the Society for Cardiovascular Magnetic Resonance (ACCF/ASE/ACEP/ASNC SCAI/SCCT/SCMR) 2007 Appropriateness Criteria for Transthoracic and transesophageal echocardiography [4] (appropriateness criteria) to classify the echocardiogram's indication as stated by the physician who requested the study, in the echocardiogram request, report or in the medical record. The appropriateness of the indication was ascertained independently by an experienced board certified cardiologist investigator.

First, the expected and observed probability of requesting an echocardiogram according to appropriateness criteria and the role of echocardiogram to alter management were analyzed. Two groups were defined based on the appropriateness criteria: the first group of patients who had an indication for the request of the study (correlating with the appropriateness criteria) and the second group, where the echocardiogram was not indicated, as they did not meet the criteria. The two groups were compared for any impact or change in management and other selected clinical variables gathered. Further, changes in clinical management of the medical condition, if any, based on abnormal results on echocardiogram were also evaluated.

For test of significance for a single proportion, an exact binomial distribution test was utilized (i.e., *bittest*) with a predetermined expected success in analyzing the following: a) proportions of echocardiograms performed according to appropriateness criteria, b) if any of these echocardiograms impacted clinical management decisions. Further, with respect to two sample comparisons of clinical variables between the groups based on appropriate indication for echo as well as clinical management changes, continuous variables were analyzed using non-parametric Mann-Whitney *U*-test and categorical variables analyzed by Fisher exact test. Odds ratios and 95% confidence intervals were also calculated. A  $P < 0.05$  was considered significant.

Using an alpha error of 0.05, our study sample although small was found to have reasonable power to detect selected differences reported in between the groups under study. Statistical analyses were performed using STATA version 8.0.

## Results

Sixty-seven patients who were pregnant or in the puerperal stage, had an echocardiogram done at LMMHC during the study period. Fifty-eight met our criteria whereas nine patients with insufficient echocardiogram

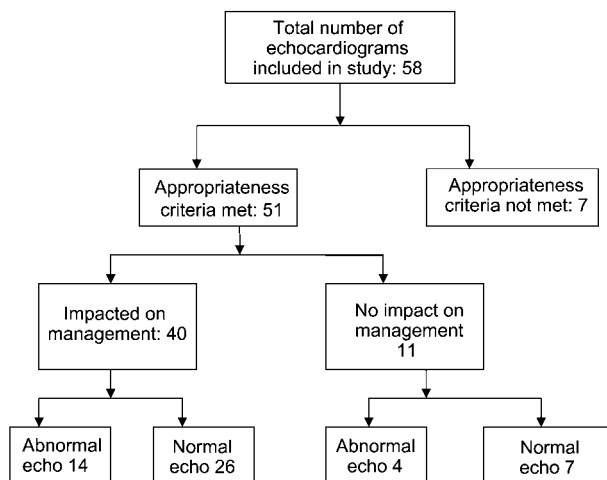
graphic data were excluded. Figure 1 illustrates the summary of study results.

About 60% of study patients were Hispanic, while 32% were African American. The mean age at the time of the echocardiography was  $29 \pm 6$  years, with a range of 16–44 years. Parity in the index pregnancy ranged from 1 to 12 with a median value of 3. The echocardiography study was done in the ante-partum period in 32 gravidas and in the post-partum period in 26 women.

Three women had multifetal gestations (2 twins, 1 triplet). Seven babies had a low Apgar score at the first minute <5, two of which were the product of a multifetal gestation. Five pregnancies ended either in abortion or stillbirth. Five patients developed pre-eclampsia/eclampsia and three had a history of pre-existing hypertension.

The most frequent clinical indications for the study were suspected or documented cardiomyopathy in 15.5%, as part of evaluation for possible pulmonary embolism in 13.7%, pre-eclampsia and eclampsia (8.6%), suspected or documented valvular heart disease in 13.7%, followed by possible congestive heart failure and cardiomegaly (8.6%), syncope (8.6%) and suspected endocarditis (6.9%) (Table 1).

The major echocardiographic findings are shown in Table 2. Forty echocardiograms showed normal structure and function or minimal and clinically insignificant abnormalities. Ten patients showed pulmonary artery pressure of over 30 mm Hg (pulmonary hypertension), which was calculated from tricuspid regurgitation peak velocity. Of these 10 patients, 7 had pulmonary artery systolic pressure below 40 mm of Hg. Of the remaining three subjects, one had prosthetic mitral valve and atrial arrhythmia, the second had respiratory failure and was on mechanical ventilation and the third had pre-eclampsia and pulmonary edema. Valvular abnormalities were found in three cases.



**Figure 1** Impact of echocardiography based on appropriateness criteria.

**Table 1** Indications for echocardiography.

Appropriate clinical indication	No. of studies	%
Suspected or documented peripartum cardiomyopathy	9	15.5
Part of evaluation for suspected pulmonary embolism	8	13.7
Pre-eclampsia and eclampsia	5	8.6
Suspected or documented valvular heart disease	8	13.7
Cardiomegaly and possible congestive heart failure	5	8.6
Evaluation for infective endocarditis	4	6.9
Previous heart surgery	1	1.7
Syncope	5	8.6
Supraventricular tachycardia	2	3.4
Other (Sickle cell disease with heart murmur, hypotension and possible sepsis and, IV drug use and heart murmur)	4	6.9

**Table 2** Major findings in echocardiography.

Findings	No. of studies	%
Normal and minimal abnormalities	40	68.9
Pulmonary hypertension (HTN), (PASP > 30 mm Hg)	10	17.2
Valvular abnormalities	3	5.1
Left ventricular hypertrophy	5	8.6
Severe left ventricular dysfunction: Ejection fraction (EF): 10–15%	1	1.7

PASP, pulmonary artery systolic pressures.

Of the 58 study subjects, we found that 88% of patients (51 cases) had appropriate indication for their request for echocardiography based on the 2007 appropriateness criteria and clinical condition of patient and the indication was inappropriate in 12% (7 cases) [ $P < 0.05$ ; 52 appropriate indications observed vs. 58 expected based on 95% probability of success]. The results of the studies led to a definitive change in the management of only 40 of the 58 patients (69%) ( $P < 0.0001$ ; 40 changes observed vs. 56 expected based on 95% probability of success).

Forty of the 51 with appropriate indications for echocardiograms had impact on their clinical management whereas none of the seven patients where echocardiogram was not indicated had any changes in management (78% vs. 0%;  $P < 0.0001$ ). Although the echocardiograms were normal in 33 of 51 patients with indications for the procedure, nevertheless they made a difference in management in these cases. Further, the sensitivity and positive predictive value for a change in management when echocardiogram was performed according to indications was 100% and 78%, respectively. When echocardiography was performed without meeting the appropriateness criteria, no change in clinical management resulted (i.e., negative predictive value = 100%).

On regression analysis, age, Hispanic background, history of diabetes or hypertension were not found to have a significant association ( $P=NS$ ) with either the appropriateness of indications or clinical decision-making changes. More echocardiograms were requested by non-cardiologists (81%) than cardiologists (19%) ( $P<0.01$ ); 11 cardiologist requests vs. 20 expected based on 35% probability of cardiologist requests based on published data [16]. The request of the study separated by services and its usefulness in the clinical setting of the patients is detailed in Table 3. The comparison of appropriate echocardiography requests by obstetric service and other medical services did not reach statistical significance (OR 0.36, 95% CI 0.07–1.88;  $P=NS$ ).

The proportion of abnormal echocardiograms in those who had appropriate indications vs. those with no indication (27% vs. 0%;  $P=NS$ ) and the association of abnormal results with changes in management (30% vs. 11%;  $P=NS$ ) were not significant. Of the 51 patients who met appropriate indications, 18 were abnormal, and the remaining 33 normal; of the 7 who did not meet the criteria, only 1 echocardiogram was abnormal. An abnormality on echocardiogram was associated with 78% positive predictive value in changing management. Of the 40 echocardiograms which impacted management, interestingly 26 studies were normal and 14 were abnormal; of the 11 studies not impacting management, 7 were normal and 4 had abnormal findings, which however did not influence management.

Indications for echocardiography were inappropriate in seven cases and are listed in Table 4.

## Discussion

Echocardiography can provide comprehensive information about cardiac structure and function, helping to establish a diagnosis and guide therapy [6]. However, echocardiography is not an inexpensive screening tool for diagnosis and has its limitations [12, 13].

The wide availability of this study makes it one of the most commonly performed cardiac investigations. Its use is no longer reserved for the cardiologist. As we show in our study, the examination request is more frequently done by doctors of other branches of medicine. Our find-

**Table 4** Inappropriate indications for echocardiography.

Inappropriate indication	No. of studies	%
Asthma	2	3.4
History of palpitation	2	3.4
Chest pain	1	1.7
Persistent tachycardia with prior normal echocardiogram	2	3.4

ings are in accord with the observations of Xu who noted an increase in the request by non-cardiologists among general adult patients [20]. It is very important for the physician to recognize signs and symptoms that may be found on physical examination or as part of the history of a normal pregnant woman or puerperal patient. Shortness of breath, syncope, prominent jugular venous pulsation, leg edema, and ejection murmurs over the aorta or pulmonary artery are clinical findings that when found separately, may not always justify a request for echocardiography.

We noted that a significant proportion (88%) of echocardiograms in our study were performed according to appropriateness criteria when used in conjunction with clinical data. However, management changes occurred in significantly fewer than expected subjects based on expectation of changes in 95% of those subjects who undergo echocardiography. When appropriateness criteria were applied, a larger proportion (78%) of the studies led to changes in clinical management, validating the clinical application of the 2007 appropriateness criteria of echocardiography in our study population. The sensitivity of echocardiogram in changing clinical management was noted to be a perfect 100% if echocardiogram was performed based on appropriate indications along with clinical condition of patients.

The appropriateness of indications was not associated to any specific clinical characteristics of the subjects. Further, we also did not find significantly inappropriate indications according to the service requesting the echocardiogram in our study.

Although we did not find an association between abnormal echocardiograms and treatment changes, normal echocardiograms led to changes in management in a large proportion of our cases.

**Table 3** Echocardiogram request by services and its appropriateness based on ACCF/ASE/ACEP/ASNC SCAI/SCCT/SCMR 2007 Appropriateness criteria for transthoracic and transesophageal echocardiography.

Request by/ criteria	Cardiology No.	Medicine No.	OB/GYN No.	Critical care No.	Emergency room No.	Unknown No.	All No.
Appropriate indication	11	23	12	2	1	2	51
No indication	0	4	3	0	0	0	7
Total	11	27	15	2	1	2	58

OB/GYN, obstetrics and gynecology.



Given our study findings, the indiscriminate use of echocardiography or its use as a screening tool in any patient should be avoided for two principal reasons. First, the cost of echocardiography is not trivial. In this regard, although the cost of echocardiography, including procedural and interpretation costs is less than that of several non-invasive and invasive cardiac tests, the cost nevertheless ranges between \$400 and \$800, with variations between institutions and locations; this should be weighed against the benefits of providing beneficial information vs. costs incurred for addressing missed diagnosis and consequent patient outcomes. Secondly, echocardiography may reveal morphological and functional details, including vestigial structures and minimal or insignificant regurgitant flow patterns, which have the potential to generate unnecessary further testing or inappropriate and potentially detrimental therapy.

Echocardiography is nevertheless useful when used appropriately based on published criteria. Our study shows that the high validity of appropriateness criteria along with clinical presentation of patient even in subjects with physiologic cardiovascular changes associated with pregnancy and puerperium. Echocardiograms when performed based on indications certainly impacted on clinical decision-making in our study. Echocardiogram results even when normal also contributed to changes in management decisions.

The ACCF appropriateness criteria were developed based on individual indications without consideration for the overall clinical picture (as stated in the report) [4]; hence, the criteria may not always be appropriate for a given situation. In our evaluation of the appropriateness, in addition to utilizing the ACCF criteria, clinical data were also factored in before arriving at the conclusions. Further, it appears that all indications in the ACCF report were for adult patients 18 years or older, with no mention of pregnant patients being part of the picture [4]. In pregnancy, physicians in general use the safest procedure available to make a specific diagnosis, with the aim of incurring the least harm to the mother and fetus. Echocardiography hence may be utilized as part of the evaluation for suspected pulmonary embolism; echocardiograms have the potential to visualize a thrombus and help differentiate massive pulmonary embolism from other causes of hemodynamic compromise [7].

In normal pregnancy, pulmonary artery pressure does not change due to decrease in pulmonary vascular resistance [18]. In our study, 10 patients had pulmonary artery systolic pressures (PASP) over 30 mm Hg, considered abnormal [13]; with improvement in echocardiographic techniques, smaller degrees of tricuspid regurgitation are detected and a mild increase in pulmonary artery pressure is not an uncommon finding in echocardiography [10]. In our patients, PASP readings between 30 and 40 mm may actually be in the normal range, as echocardiography can overestimate PASP compared with catheterization in pregnancy [13].

A limitation of our study is the sample size. However, the power to detect selected differences noted among study groups was acceptable. Determination of the changes in clinical management was completed through chart review and therefore can be limited by extent of documentation. In view of this, two independent board certified attending physicians including a cardiologist reviewed the clinical data to ascertain that validity of changes in management and minimize bias.

As pre-eclampsia may be an early indicator of cardiovascular disease risk [11] we believe the use of echocardiography offers valuable information in this state; although use of echocardiography in pre-eclampsia was not evaluated for appropriateness in the ACCF guidelines, requests for echocardiography in pre-eclampsia in our hospital study were common and to our belief were justified. In the future, use of echocardiography early in gestation may be used as a screening tool to predict maternal and fetal complications [17].

## Conclusions

Our study validates the utility of the ACCF 2007 appropriateness criteria among pregnant and post-partum women with physiologic cardiac changes when used with the clinical data. Although clinical management decision did not change in all cases, echocardiography when used appropriately helped significantly in clinical decision-making. While many study subjects had echocardiographic findings that were normal, this nevertheless had an effect on management decisions on these patients.

Further studies with larger sample size in different settings and prospective design are necessary for better understanding and appropriate utilization of the practice of echocardiography in pregnancy and the puerperium.

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